oxygen, while but a trace of carbon dioxide had been added to it. The water in which it had been immersed had received, however, a much greater amount of carbon dioxide than could have been formed from the free oxygen taken from the water.

2. Tadpoles were placed in a jar partly filled with water, and the jar hermetically closed. After several hours, the air was analyzed, and the free gases in the water determined. These determinations showed that nine tenths of the oxygen consumed came from the air, and one tenth from the water; while, of the carbon dioxide produced during the experiment, the air contained three tenths, and the water seven tenths.

In order that the carbon dioxide given off by the tadpoles to the air might not be absorbed by the water during the experiment, a layer of olive-oil six millimetres thick was put upon the water.

3. It was found by careful and repeated observations, under perfectly natural conditions, that frogs in cold weather (so-called 'winter frogs'), in water at 0° to 15° C., remain with their heads above the surface from one-tenth to one-half the time, and while above the surface carry on from eight to twenty lung respirations per minute; showing, that, under natural conditions, the respiration of 'winter frogs' is not entirely or almost entirely carried on aquatically by the skin, as is commonly supposed (Klug and Martin).

4. The results obtained by Moreau and others, upon the respiratory function of the air-bladder of ordinary fishes, and those of Wilder, on the respiration of Amia (the mud-fish), are in general accord with the facts stated for turtles and tadpoles.

These facts seem to us to justify the conclusion that the respiratory gas-interchange in combined aerial and aquatic respiration does not conform to the law governing either exclusively aerial or exclusively aquatic respiration, but that, whenever aerial and aquatic respirations are combined in an animal, the aerial part of the respiration is principally to supply oxygen, and the aquatic part to get rid of carbon dioxide. S. H. and S. P. GAGE.

Anat. lab., Cornell univ.,
April 15.

## Pharyngeal respiratory movements of adult amphibia under water.

In studying adult amphibia for possible respiratory movements under water, we have found that the common newt (Diemictylus viridescens) so abundant in lakes and ponds, and which is known to remain voluntarily a long time under water, carries on, while under water, rhythmical pharyngeal movements almost precisely like those of the soft-shelled turtles; and, as in the turtles, these movements cause a flow of water into and out of the mouth and pharynx.

The Cryptobranchus (Menopoma) has also been found to draw water into the mouth, and to expel it, in part at least, through the persistent gill-fissures.

So far as we know, these facts have not been published before. We would be glad to know if these observations have been previously made on Diemictylus and Cryptobranchus, and if similar pharyngeal movements under water have been described for other adult amphibia. S. H. and S. P. GAGE.

Anat. lab., Cornell univ., April 25.

## The germination of pond-lily seeds.

In the issue of *Science*, March 21, 1884, there appeared a conditional offer of seeds of the Nymphea odorata, obtained by me in the fall of 1883, the growth of that year. Many of the seeds at this time were germinating; some had developed the second leaf. There was a marked difference in color; the variations were, in shades of red, from blood-red to light pink, from dark blue-green to light yellow-green, and from a dark bronze to a light salmon. It seemed to me, with varying and suitable culture, new varieties might be obtained, as the seeds are not always to be had, and the method of germination is not a matter of every-day observation. A number of applications were received, but I have not heard from any one, of successful culture, nor whether all or any of the seeds germinated. A succession of germinations gave me new plants to take the place of those destroyed by Unios, ferments, or fungi. The seed were kept under water, on sand, exposed to a north light, or that reflected from the brick houses on the north side of the street, fifty feet distant.

In June, 1855, I removed from the water all light seed, and those that were softened, as well as all on which fungoid growths had appeared, and placed the vessel in an open space where it had vertical light, and from the sun, for an hour between eleven and twelve in the morning in clear weather. A half-dozen new plants appeared in August, as the result of the change. When the cold weather came in the fall, I restored them to their old position in the north light, slightly obscured by ferns, Zygodium scandens and Pteris serrulata. About last Christmas I observed a new plant that had germinated since being brought in in the fall. This plant was removed to some submerged soil in another vessel, where it is now putting forth its fourth leaf. In February another seed germinated; and, since the 20th of March, three others have begun to grow. The last one was observed on the 3d of April. There are a few more very heavy seed in the water. The first plants from these seed that germinated early in 1884 — beginning in January — were peculiar in the length of the internodes, all being very long, some over an inch; and the seeds, before germination, were very light, and quite variable in color, but not as much so as the foliage.

The germinations of 1885 have shorter internodes, smaller leaves, of an even green color, whilst other germinations of this year have the internode reduced to a minimum; the leaves seem to start from the very dense and dark seed; and the foliage is variable in size and color, but mostly in light shades of bronze — salmon — with shades of pink.

The seeds varied in their development when taken from the pond in which they grew.

Some of the plants had just begun to coil the flower-stem by which to draw the seed down to the bottom of the pond; one had finished coiling, and the seed-vessel was in the mud; others were midway between these extremes. I mention this to show that there were natural and well-known causes for the variance in time of germination.

When it is known that the ripe and fully matured seeds are very dense, it will not seem so strange, that, considering the great number of seeds to a single flower, all ponds are not overcrowded, as by their density they sink into the ooze and remain dormant.